PRODUCTION OF A BLAND SIRUP FROM APPLES

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This Laboratory has recently developed a bland, very sweet sirup from apple juice. It is light amber in color and possesses no distinctive flavor, even apple flavor. With 75 percent solids, the sirup contains on an average 40 percent levulose, 13 percent dextrose, 14 percent sucrose, and 8 percent nonsugar solids. Although certain details of the process need further study, it is believed that the main features are established and that it is commercially feasible. We think this product should be called to the immediate attention of apple processors and other interested parties for the following reasons:

1. There is an urgent need for every possible source of sugar, and the apple is one of them.

2. Preliminary findings indicate that apple sirup would be accepted by a number of industries and probably by home consumers.

3. The process is simple, and could be undertaken by any group possessing the required equipment.

4. Plans for manufacturing the sirup should be made as far in advance of the season as possible to get the necessary equipment installed in time to handle the crop in season.

The apple has never been considered seriously as an industrial source of sugar in spite of the fact that its juice contains about 11 percent of sugar. A reason for this is found in the facts that rather low-priced apples are required to compete with the usual sources of sugar and that only a sirup and not a dry sugar can be obtained from apples. Today all possible domestic sources of sugar products are being re-examined because of the shortage of cane and beet sugars. In cane and beet juices, the predominant sugar is sucrose, with traces of dextrose and levulose. In apple juice, levulose represents 58 to 75 percent of the total sugars; the dextrose and sucrose are present in about equal amounts. This combination of sugars is very desirable for a sugar sirup on account of the great sweetening power of levulose, which makes this sirup 20 to 30 percent sweeter than a cane sirup of equal sugar content. It is worthless, however, as a source of crystalline sugar, owing to the difficulty of crystallizing levulose.

In addition to sugars, apple juice contains small amounts of malic acid, tannin, pectin, amyl esters of formic, acetic, and caproic acids, soluble salts, coloring matter, and nitrogenous substances consisting of enzymes, proteins, and possibly some free amino acids.

Investigations have been conducted at the Eastern Regional Research Laboratory with the view of eliminating the substances that impart flavor, odor, color, and jellification to apple juice, leaving a more or less flavorless sugar solution that can be evaporated under vacuum to a sirup somewhat similar to commercial invert sirup, which is well known in the bakery, ice cream, soft drink, and other food industries. This objective has been achieved, to the degree that several industrial users have pronounced the sirup satisfactory, and a number of people have declared it an excellent table and cooking sirup. Because of the present demand for sweetening agents, it is believed the time is ripe for producing this sirup. It should be understood, however, that only the major steps in the process have been worked out; a number of minor details require further study. Prospective users of the process will be kept informed of further developments.

In our experiments 15 gallons of juice was processed in each run. The limed juice was filtered through 8 surfaces of a 10- by 10-inch aluminum plate-and-frame filter press. The clarified juice was concentrated in a 15-gallon stainless steel vacuum pan. Ten gallons of juice was drawn into the pan, 5 gallons was evaporated, the remaining juice was drawn in, and the whole was then evaporated to about 2.5 gallons of finished sirup.

EQUIPMENT REQUIRED

The main items of equipment needed for production of sirup by this process are the following:

- Apple sorting belt
- Apple washer
- Hammer mill or grater
- Hydraulic cider press
- Small tank with stirrer, for preparing milk of lime
- Large tank with heating coils or jacket and stirrer, for liming the juice
- Glass-electrode pH meter, or colorimetric pH outfit
- Filter press
- Tank for clarified juice
- Vacuum pan or other vacuum evaporating equipment, with necessary condenser, source of vacuum, and means for removal of condensate
- Source of steam for heating and evaporating
- Pumps, miscellaneous tanks, scales
- Barrels for finished sirup

PROCESS

The process in general is shown in the accompanying flow sheet. The apples are washed to remove spray residues and ground in a hammer mill, and the juice is extracted by means of a hydraulic press. The juice is treated with a slurry of hydrated lime until the pH value is 8, heated to 175°F. (79°C.), and filtered. The clarified juice from the filter press is treated with dilute sulfuric acid (1-3) until the pH value is between 5 and 5.5 and then evaporated to a sirup containing approximately 75 percent of solids.

Sorting, Washing, and Grading

Federal laws prohibiting the use of unsound apples in food products necessitate preliminary sorting to remove unsound fruit.

Apples may contain appreciable quantities of spray residues, which find their way into the juice upon extraction. In processing, the juice is reduced in volume by evaporation, and thus the spray residues are also concentrated. Therefore to prevent excessive amounts of the residues in the finished sirup, it is advisable to wash the apples by any of the accepted methods for removing spray residues.

No attention has been given to the effect on the sirup of the quality and variety of the apples. A "juice" grade of apples, consisting of fruit that is sound but perhaps off-grade because of color, size, shape, or surface defects, is satisfactory. Very immature fruit is to be avoided because it has a low sugar content. Overripe fruit is difficult to handle in a hydraulic press. Most of our experiments have been made on frozen juice from sound fruit held in cold storage until midwinter. Varieties used were Winesap, Delicious, York, Stayman Winesap, and Grimes Golden. All were satisfactory. The possibility of using summer apples is being investigated.

Grinding and Pressing

The clean sound apples received from the washer are passed by means of an elevator to a hammer mill, where they are ground. The juicy pulp goes to a hydraulic press, where the juice is extracted. If the pomace is to be dried, a second pressing will greatly facilitate the drying operation. Although we have not used second-pressing juice for sirup production, we believe it will be satisfactory. The extracted juice flows by gravity or is pumped to a receiving tank equipped with means for heating and stirring.

Liming

The juice, which must not be below 78°F. (25°C.), is limed to pH 8 (plus or minus 0.2) by the addition of a slurry of lime containing 1 pound of hydrated lime per gallon of water. If the temperature is below 78°F. (25°C.), there is danger of precipitating a lime-sucrose compound. During the addition of the lime, vigorous stirring is necessary to prevent localized action of the lime on the invert sugars. The amount of lime necessary depends on the acidity and pectin content of the raw juice; it is usually about 3 gallons of slurry per 100 gallons of juice. A pH meter, preferably a glass-electrode type equipped with extension leads, may be used to control the addition of lime. If such an instrument is not available, indicators may be used.

The lime-treated juice is then heated to 175°F. (80°C.) to accelerate the action of the lime on the pectin.

Filtration

An aluminum plate-and-frame filter press was found satisfactory for the filtration of the hot, lime-treated juice, but unquestionably other types of filters could be used. Wood, stainless steel, and possibly ordinary steel would also be satisfactory materials for the filter press. This operation is merely to clarify the juice so that the sirup will be free from suspended matter. Diatomaceous filter aid is used to precoat the filter, and it is also added to the hot, lime-treated juice. Approximately 4 pounds of filter aid is used per 100 gallons of juice. For each square foot of filtering area, from 60 to 100 gallons of juice may be filtered before cleaning is required.

Reacidifying

The juice as received from the filter press is sparkling clear and dark brown in color. The pectin and other colloidal material have been removed, and the malic acid has been neutralized. The juice is now made slightly acid (pH value of 5 to 5.5) in order to improve the color, eliminate the alkaline taste, and avoid the effect of an alkaline reaction on the levulose. Sulfuric acid is used for this purpose. It is made by adding 1 volume of U.S.P. grade concentrated acid to 3 volumes of water. Caution! Never add the water to the acid. About 14 to 17 ounces of the dilute acid are required per 100 gallons of juice. During the acidification the color of the juice changes from dark brown to very light straw color.

Use of Activated Carbon

If a more highly clarified, very bland, light-colored sirup is desired for certain purposes, the acidified juice may be treated with activated carbon. Two to four pounds of carbon, depending on the grade of carbon and the degree of improvement desired, gives satisfactory results. The carbon is added to the acidified juice, and the mixture agitated to keep the carbon in suspension. At the same time the temperature is brought to 150°F. (65°C.), and the juice is again filtered. Great care must be exercised in completely removing the carbon. A filter aid of fine porosity should be used, and the juice should be recirculated through the filter until it is certain that all particles of carbon are being retained. Instead of a filter aid, fiber filter pads of fine porosity may be used.

Evaporation

The clear, faintly acid juice, whether treated with carbon or not, is evaporated in a vacuum pan to a sirup of about 75 percent solids (75° Brix). Excess foaming during evaporation is avoided by the addition of about two-thirds of an ounce of refined corn oil or other bland oil per 100 gallons of juice. A vacuum of 25 inches is required, at least during the finishing stages, since the higher boiling temperature accompanying a lower vacuum darkens the sirup and gives it a poor flavor.

In most of the work, a stainless steel evaporator was used. Three runs were made in a small copper evaporator. Analysis of the sirup from the third run showed 26 parts per million of copper. The amount of copper dissolved is not considered excessive, and it imparted no metallic flavor to the sirup. In larger apparatus, with the surfaces kept bright, probably even smaller amounts of copper would be dissolved. Steel evaporators would probably be unsatisfactory, because of the risk of contaminating the sirup with iron.

In our work so far, only a double-bottom type of vacuum pan has been used. A calandria type would probably be suitable, provided the rate of flow through the tubes was sufficient to prevent localized overheating of the sirup during the finishing stage. Multiple-effect evaporators may be satisfactory, with certain restrictions. In such evaporators the boiling temperature in the first effect is relatively high, which may give the juice a poor flavor. Furthermore, it is usually difficult to concentrate to 75° Brix in a multiple-effect evaporator. In some cases it may be possible, with changes in piping, to use only one or two of the effects and avoid the difficulties mentioned above.

COST OF MANUFACTURE

At present we have no definite figures on which to estimate the cost of manufacturing this sirup. Perhaps the soundest basis for estimating the cost is found in the present price of concentrated apple juice, the labor and process involved being about the same for both products. Vacuum-concentrated juice produced from the 1941 crop of apples sold for 75 to 80 cents per gallon; the price for a similar concentrate for 1942 will probably be 90 cents to a dollar per gallon. This implies an overall manufacturing cost of about 60 to 70 cents per gallon.

Some information is available on a few of the items that enter into the cost. Probably the largest single item is the cost of the apples. Assuming an average Brix of 13.5 in the juice and a yield of 150 gallons of juice per ton of fruit, and allowing for cullage and loss in process, 1 ton of fruit yields about 21 gallons of sirup of 75° Brix. Thus the cost of raw material for a gallon of finished sirup is 4.7 cents for each dollar per ton paid for the apples. The cost of filter aid, lime, and sulfuric acid is about 1 cent per gallon of sirup. The cost of used whiskey or wine barrels for containers at $3 each is 6 cents per gallon of sirup. To these items must be added labor, factory and administrative overhead, selling, and delivery. These vary so greatly with the size of operation and with the individual plant that no attempt has been made to estimate them.

POSSIBLE SELLING PRICE

For some purposes, apple sirup will find its own market on the basis of its merits. For food purposes, it will be valued largely as a sweetening agent. For this, it will be superior to corn and sorghum sirups, about equal to maple sirup, and somewhat inferior to invert sirup and honey. For tobacco products, its sweetness will be less important than its humectant and burning properties. Its value for this purpose will depend largely on the demand, and cannot be predicted at present.

USES

Apple sirup contains the same sugars as honey but in different amounts, having more levulose and sucrose and less dextrose. Thus it is sweeter than honey. Because of this sweetness and because it has no pronounced flavor, the sirup may be adapted to some uses for which honey is satisfactory. The sirup may cost too much for exten ·e use in low-priced beverages or in the preserve industry. Moreover, the phosphates and nitrogen compounds contained in the sirup would provide nutrients for the growth of micro-organisms in an unpasteurized beverage. The flavor is also apparent in some beverages when appreciable amounts are used. Ice cream offers a definite possibility for using the sirup to replace part of the sugar in the mix. Its hydroscopicity suggests the use of apple sirup as a humectant in place of glycerin in conditioning tobacco. Some sugar is used at present for this purpose, and levulose has good burning characteristics. Several tobacco companies have tried it in pipe, cigarette, and chewing tobaccos, and now wish to have a source of supply developed. The bakery and confectionery industries are being supplied with samples and may also be expected to consume appreciable quantities.

A number of samples of the sirup were distributed to members of the staff of this Laboratory for trial as a table sirup and as a substitute sweetener. It was tried on cereals, hot cakes, and grapefruit, in tea and coffee, and in making baked beans. All the reports were favorable, but several declared that the sirup was too rich and sweet for table use. A housewife used the sirup in place of cane sugar in making apple, cherry, and rhubarb pies, and reported excellent results.

QUANTITY AVAILABLE

According to statistics, in a normal year there should be enough unmarketable but sound apples throughout the country to produce one or two million gallons of this type of sirup, exclusive of the regular apple juice concentrate. In 1942 there may be a greater supply, owing to lack of export markets, lack of cans for juice and other apple products, and an expected large crop. The real limitation, however, is believed to be the shortage of vacuum evaporators. If new evaporators cannot be obtained, it is suggested that evaporators used for other products, such as milk, fruit juices, and tomatoes, be used for apple sirup. Because of the possible lack of evaporators, however, it is useless to try to predict the amount of sirup that can actually be made in 1942.

Process of Making Apple Sirup